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OPEN-WATER PROPELLER PERFORMANCE IN INCLINED FLOW.(U)

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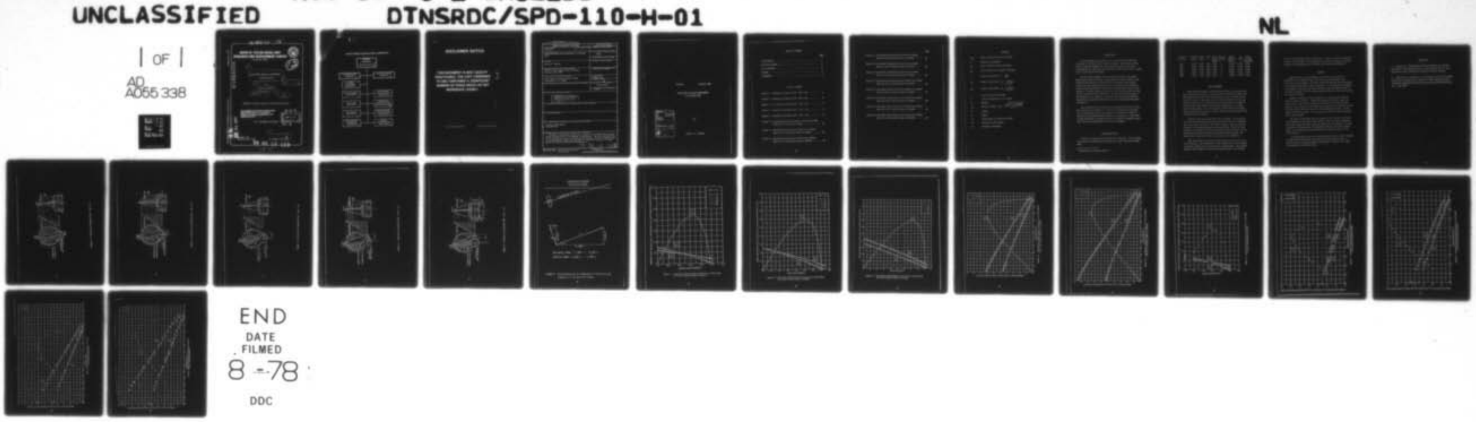

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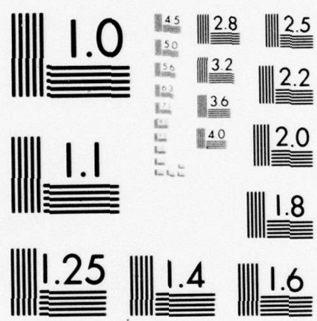

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OPEN-WATER PROPELLER PERFORMANCE

IN INCLINED FLOW.

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Curtis E./Shields

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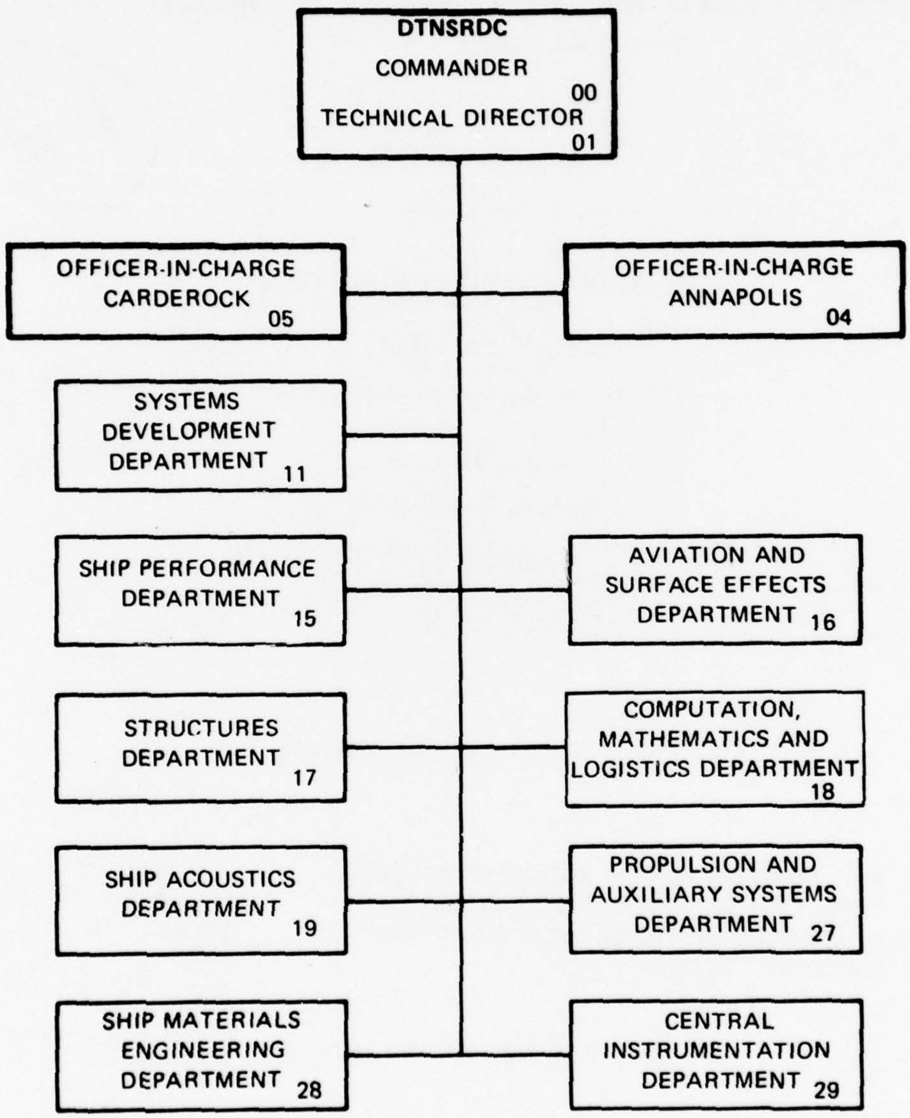

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ABSTRACT

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Results of open-water tests with a series of five propellers at shaft angles varying from 0 to 15 degrees are presented. The five propellers are of the same design but with different pitch ratios. Within a limited scope of investigation, attempt has been made to determine the effect of shaft angles on propeller open-water performance.

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110-H-01 November 1965

OPEN-WATER PROPELLER PERFORMANCE IN INCLINED FLOW

by

Curtis E. Shields

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NOTATION

$b_{0.7}$	Blade section length at 0.7 radius
D	Diameter of propeller
F_1	Force along the shaft centerline
F_2	Force normal to the shaft centerline
J	Speed coefficient, $J = \frac{V}{nD}$
K_q	Torque coefficient, $K_q = \frac{Q}{\rho n^2 D^5}$
K_t	Thrust coefficient, $K_t = \frac{T}{\rho n^2 D^4}$
n	Revolutions per unit time
P	Pitch of propeller at 0.7 radius
Q	Torque
R_e	Reynolds number, $R_e = \frac{b_{0.7}\sqrt{V^2 + (0.7\pi nD)^2}}{\nu}$
T	Thrust
V	Speed
α	Shaft angle to direction of flow
ρ	Density of fresh water
ν	Kinematic viscosity

INTRODUCTION

The performance of propellers in inclined flow has long been a subject of interest to the naval architect. It is rare, if ever, that a propeller operates in a true axial flow since most shaft installations on ships and, particularly on small craft, are at angles to the direction of free flow.

To aid in the analysis of model propulsion tests, the David Taylor Model Basin initiated a test program to obtain limited information on the effects of inclined flow on propeller performance. A series of five propellers of the same design but with different pitch ratios were tested in open water at shaft angles from 0 to 15 degrees. For this series of tests, the only force measured was that in the direction of the shaft axis. The side force that occurs on the propeller at an angle of inclination has been investigated by Gutsche[1] and cavitation effects have been investigated by Taniguchi and Chiba.[2]

The objective of the limited study presented here was to determine whether or not there was a sufficient difference in the open-water characteristic curves at various shaft angles to warrant a correction when predicting ship propulsion performance. Prediction of ship performance is often based on the results of propeller open-water tests and a propulsion test is not conducted.

PROPELLERS TESTED

Figures 1 through 5 show the propeller drawings. The following table shows the TMB propeller numbers with their respective design data.

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[1] References are listed on page 4.

Propeller No.	Diameter in.	Pitch in.	P/D	Mean Width Ratio	No. of Blades	Total Projected Area	$\frac{PA}{DA}$	Blade Thickness Fraction
826	8.00	9.60	1.20	0.40	3	25.20	0.501	0.050
827	8.00	8.00	1.00	0.40	3	26.76	0.532	0.050
828	8.00	6.40	0.80	0.40	3	27.90	0.555	0.050
829	8.00	4.80	0.60	0.40	3	28.83	0.573	0.050
830	8.00	3.20	0.40	0.40	3	29.64	0.589	0.050

TEST PROCEDURE

Only slight deviations from the normal TMB test procedures were necessary for this program. To obtain the desired shaft angles, the TMB propeller boat was tilted with respect to the direction of the speed of advance. The water level in the TMB deep-water basin was lowered three feet to accommodate the increased vertical height of the propeller boat mounted at the higher shaft angles. At these higher shaft angles, it was necessary to install the TMB pendulum-type dynamometer backwards so a larger thrust and torque range could be achieved on the scales.

Briefly, the actual tests were run as follows: The propeller was rotated at constant rpm and the speed of advance was increased until the thrust read zero. The thrust, torque, rpm, and speed of advance were recorded throughout the speed range. With this test approach, the propeller thrust was measured in the direction of the shaft and not in the direction of the free-stream velocity. No measurements were made of the side forces on the propellers.

The propellers were tested at shaft angles of 0, 3, 6, 9, 12, and 15 degrees. The submergence of the propellers was held between 13 and 21.5 inches for 0 to 15 degrees, respectively. Shaft angles greater than 15 degrees could not be obtained due to the limited

travel of the pendulums in the dynamometer. Reynolds numbers varied from 6.128×10^5 to 13.160×10^5, depending on the thrust and torque loadings imposed on the dynamometer by the pitch ratio and rpm combinations.

RESULTS

Figure 6 shows a vector diagram of the forces occurring on a propeller in the vertical plane. In the data presented here, the force F_2' was not measured. For this reason the measured forces have not been resolved into their various components. It is impossible to define a meaningful efficiency since the velocity vector and force are not in the same direction, so in the following plots only the efficiency for the zero angle is given.

Figures 7 through 11 show a propeller of a given pitch ratio at various angles of attack. Figures 12 through 16 show test spots for these curves. The data in the figures show that the effect of shaft angle up to 15 degrees on the force in the direction of the shaft axis is not much greater than the scatter of the experimental points. In any future tests of this type, it is necessary to achieve greater precision in the measurements.

It must be understood that the results of this report do not show a full picture of the shaft angle effects. There are force components other than along the shaft centerline which were not measured. No less important is the phenomenon of cavitation which was not studied since there is no provision for running tests at arbitrary angles in the water tunnels.

Any application of the test results in this report should certainly be applied with discretion since only a partial study was made. A further study of overall propeller performance in inclined flow might be desirable at some future date.

REFERENCES

1. Gutsche, F., "Untersuchung von Schiffschrauben in schrager Anstromung," Schiffbauforschung 3, Jahrgang (1964) Heft Nr. 3/4, Seite 97 bis 192, Institut fur Schiffbau, Rostock, Germany.

2. Taniguchi, K. and Chiba, N., "Investigation into the Propeller Cavitation in Oblique Flow," Report No. 1800, Experimental Tank (Nagasaki) Laboratory, Mitsubishi Shipbuilding and Engineering Co. Ltd., (May 1964).

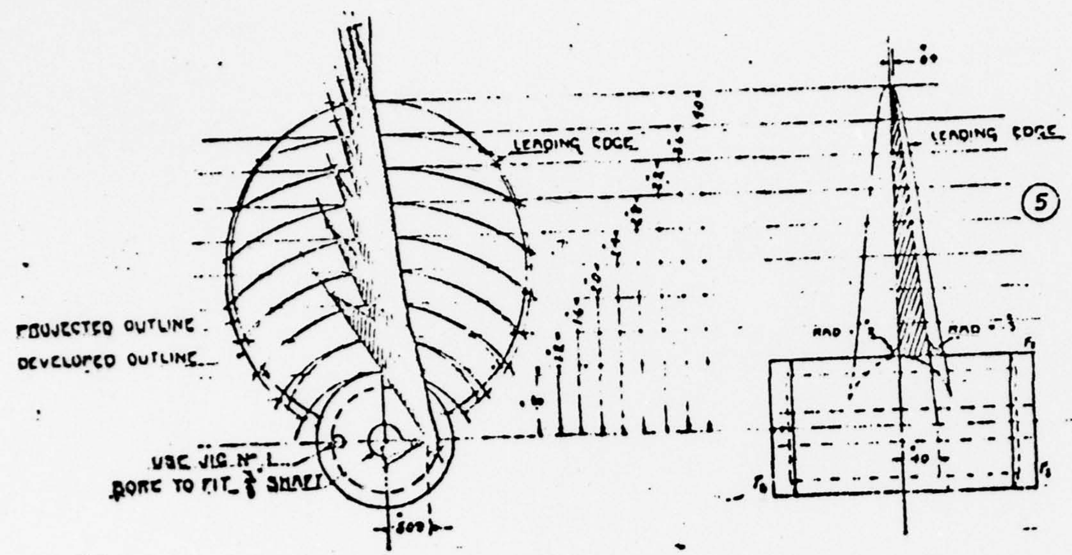


Figure 1 - Drawing for Propeller 830 - P/D = 0.4

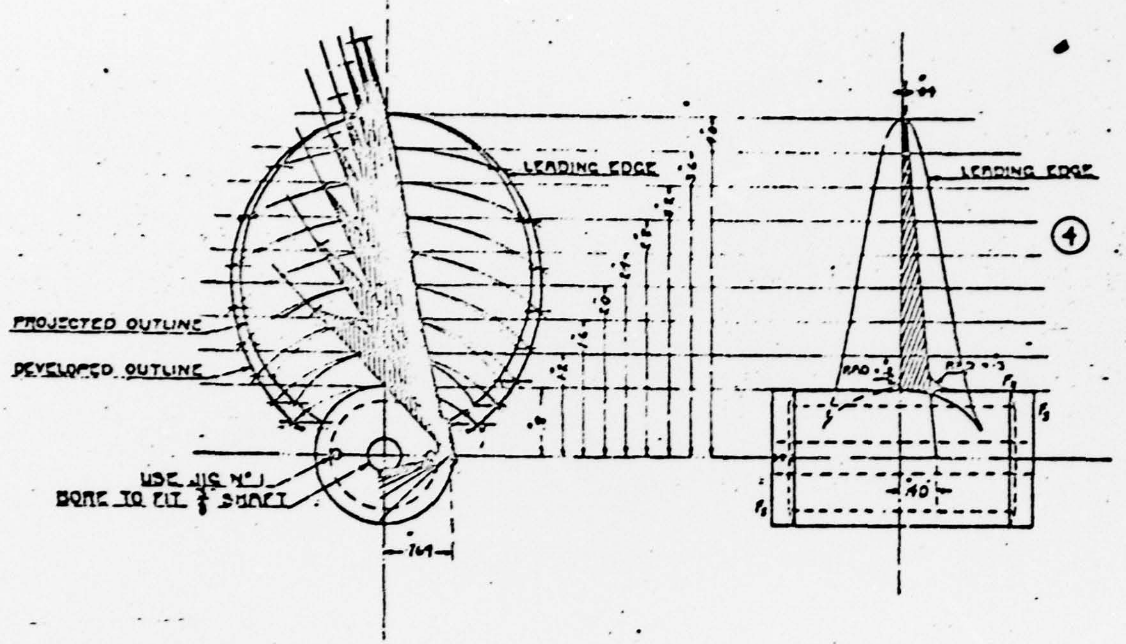


Figure 2 - Drawing for Propeller 829 - P/D = 0.6

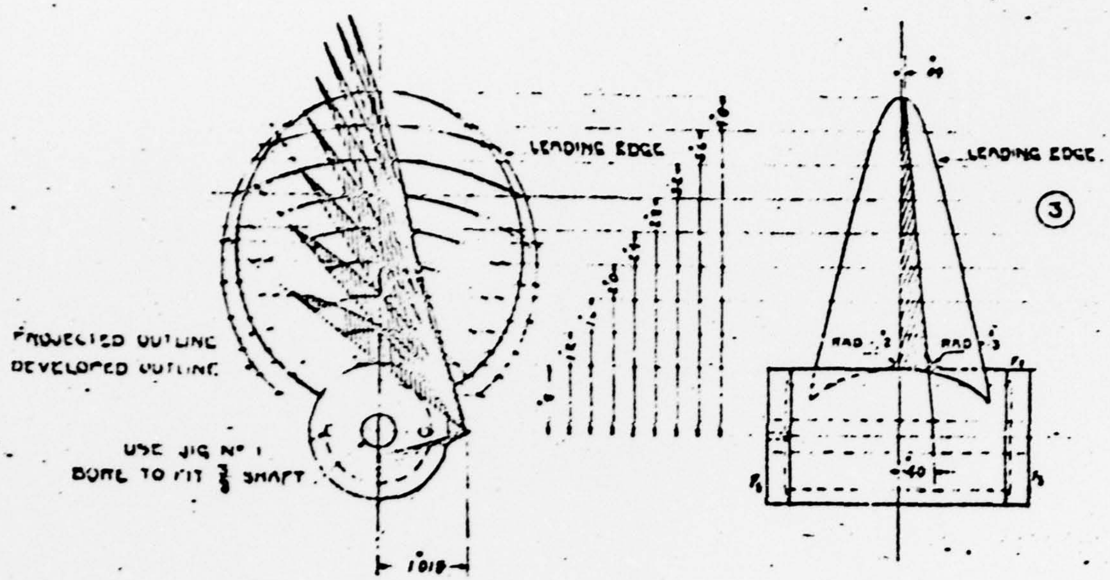


Figure 3 - Drawing for Propeller 828 - P/D = 0.8

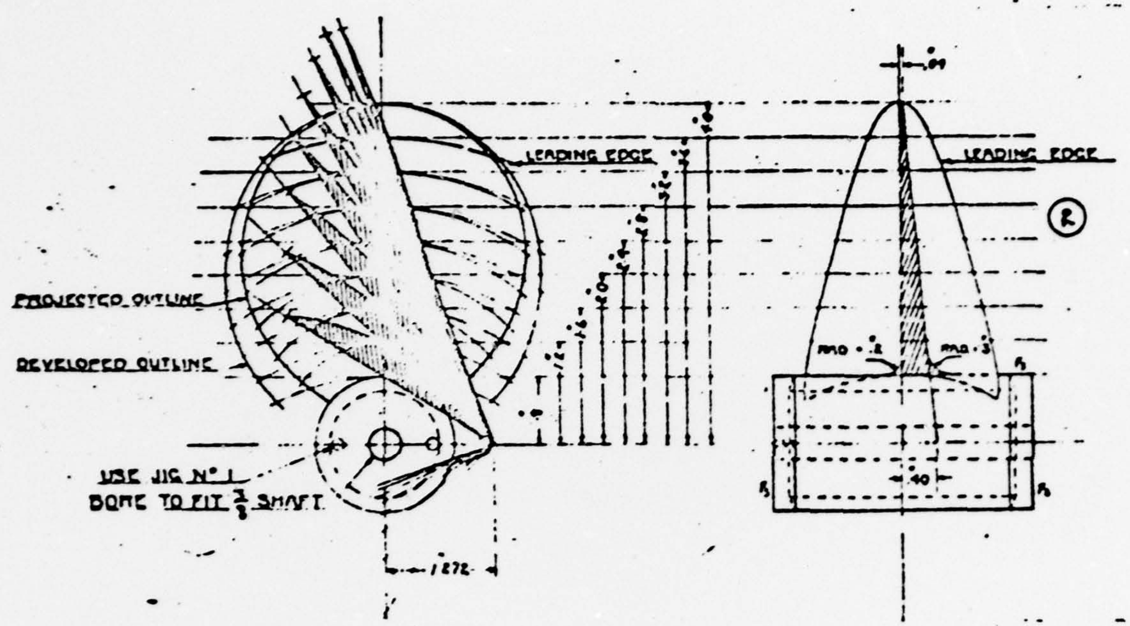


Figure 4 - Drawing for Propeller 827 - P/D = 1.0

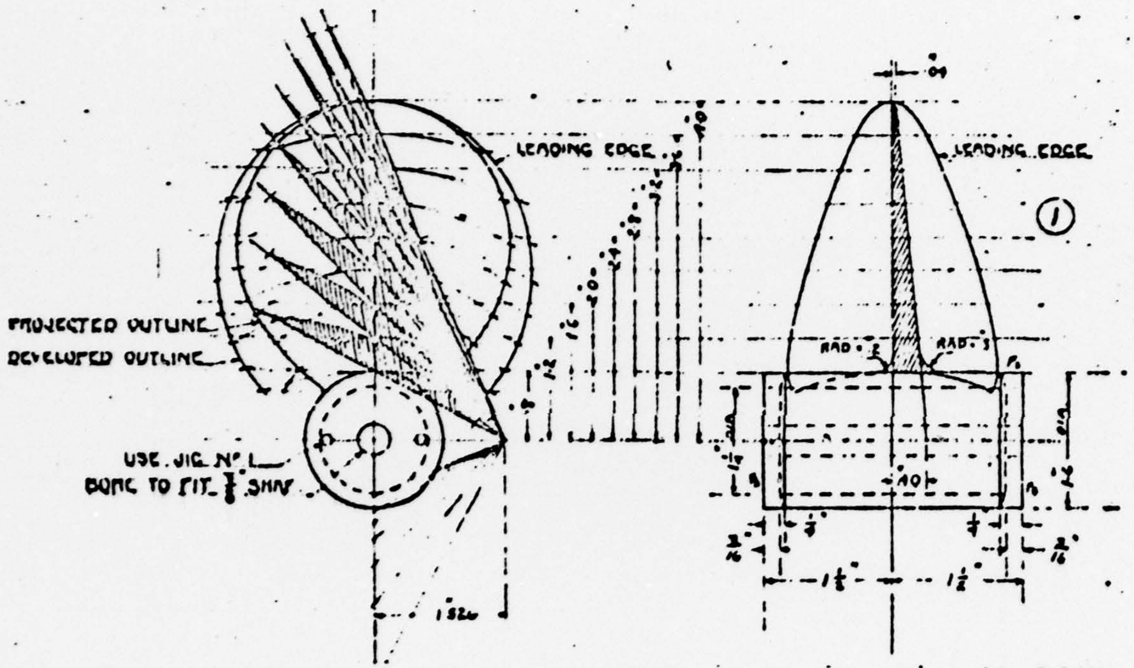
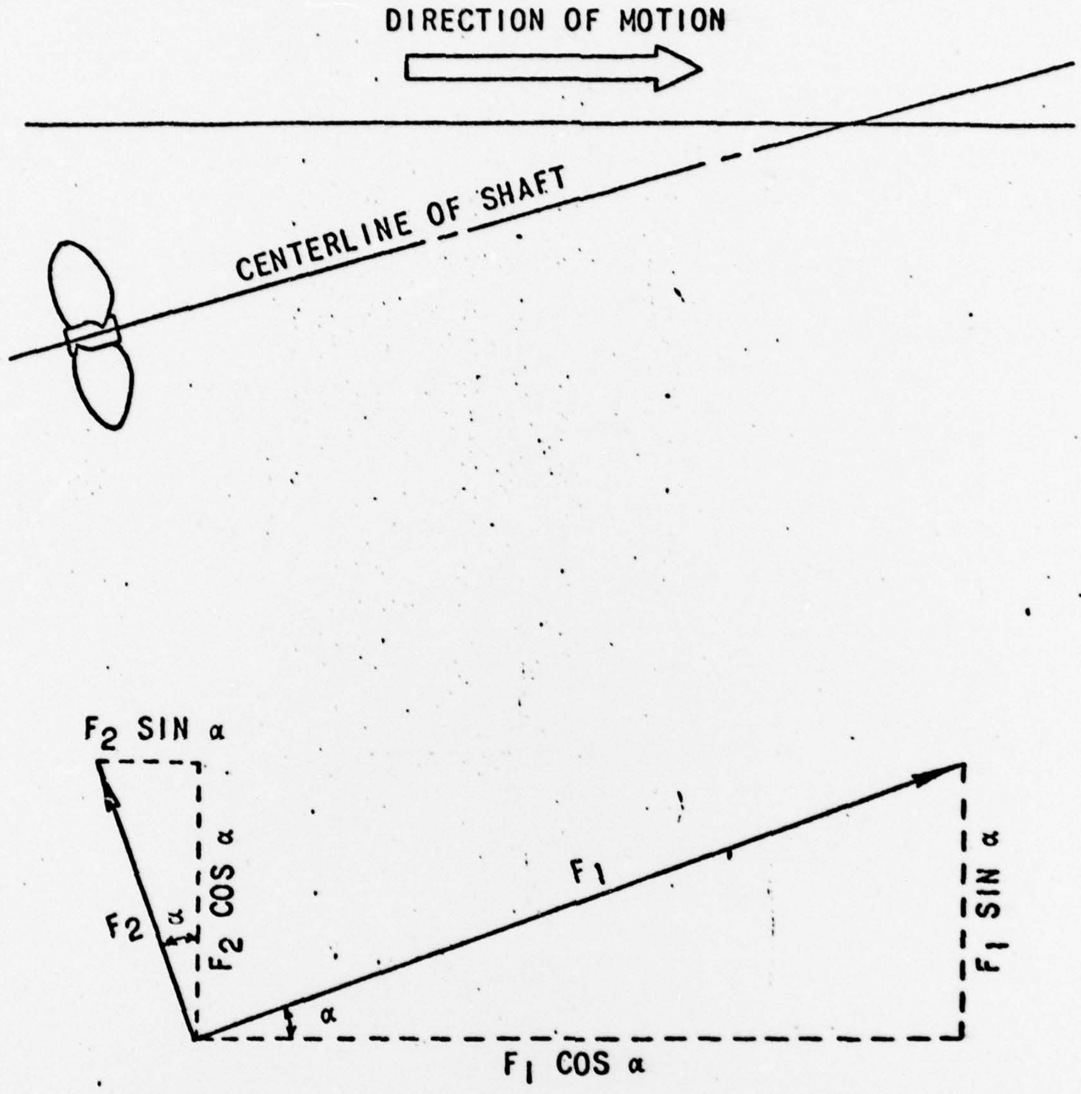


Figure 5 - Drawing for Propeller 826 - P/D = 1.2



HORIZONTAL FORCE = $F_1 \cos \alpha - F_2 \sin \alpha$

VERTICAL FORCE = $F_2 \cos \alpha + F_1 \sin \alpha$

FIGURE 6 - Diagram Showing the Components of Forces on the Propeller in the Vertical Plane.

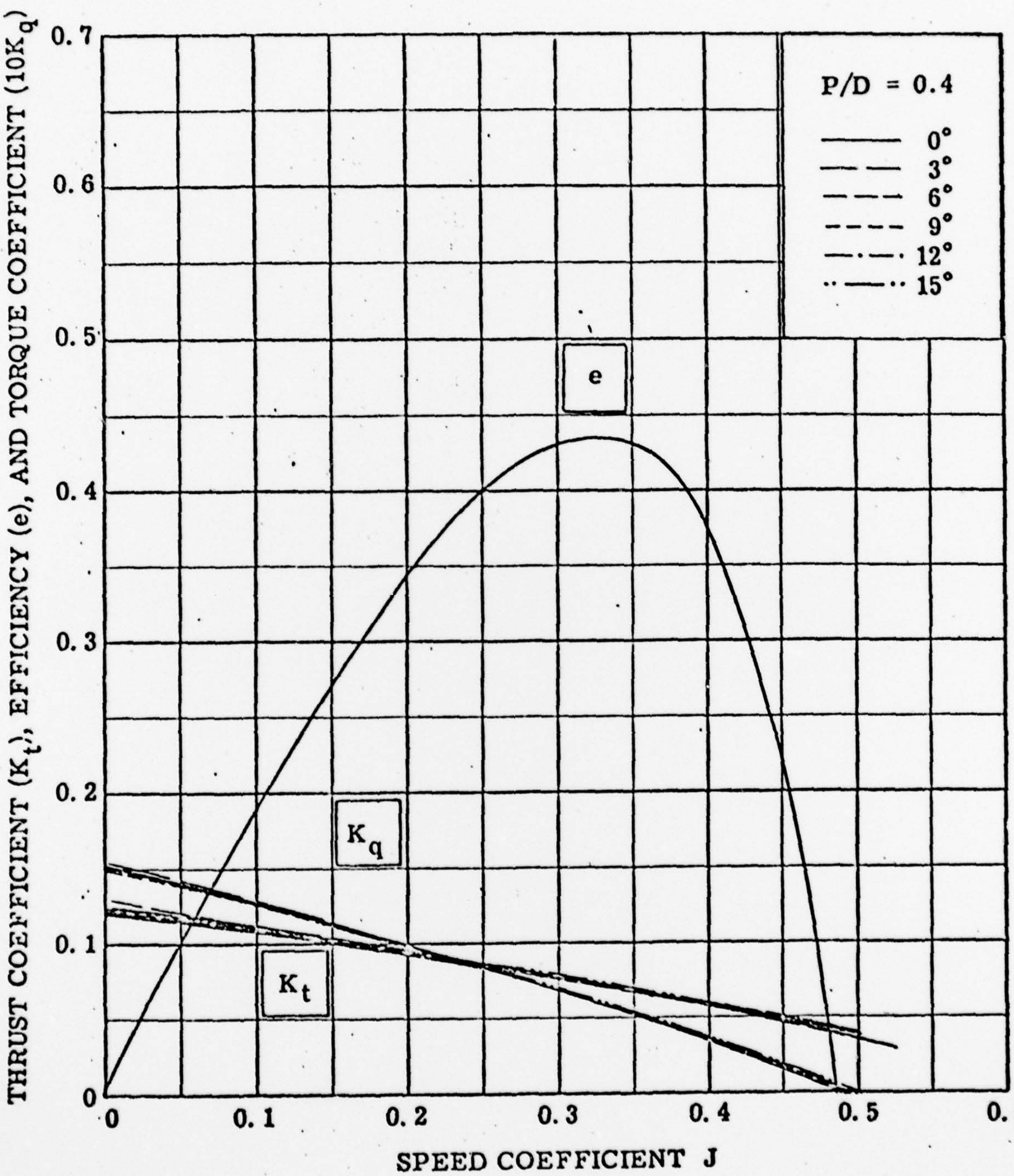


Figure 7 - Open-Water Characteristic Curves for a Pitch Ratio of 0.4 at Various Angles of Attack

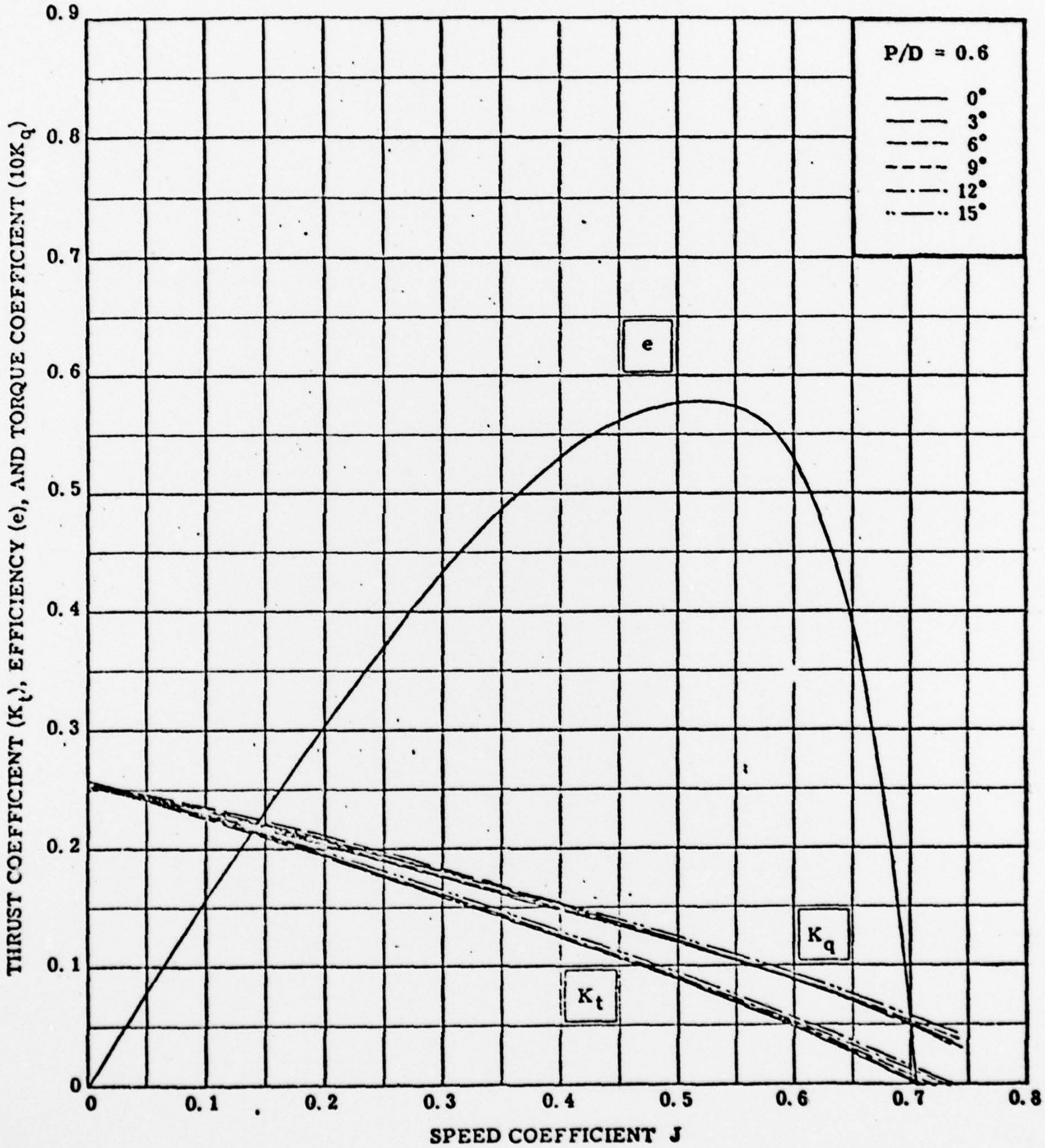


Figure 8 - Open-Water Characteristic Curves for a Pitch Ratio of 0.6 at Various Angles of Attack

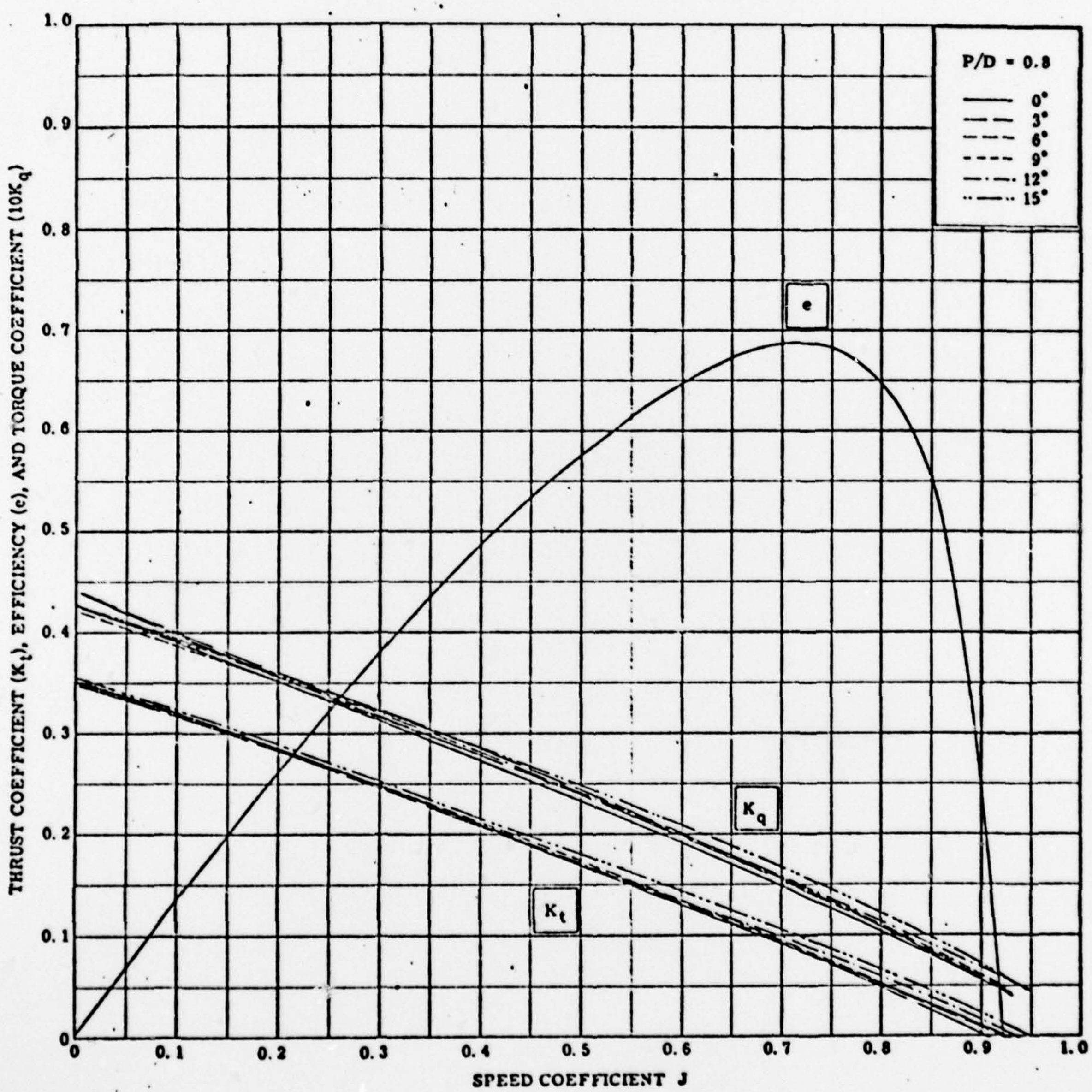


Figure 9 - Open-Water Characteristic Curves for a Pitch Ratio of 0.8 at Various Angles of Attack

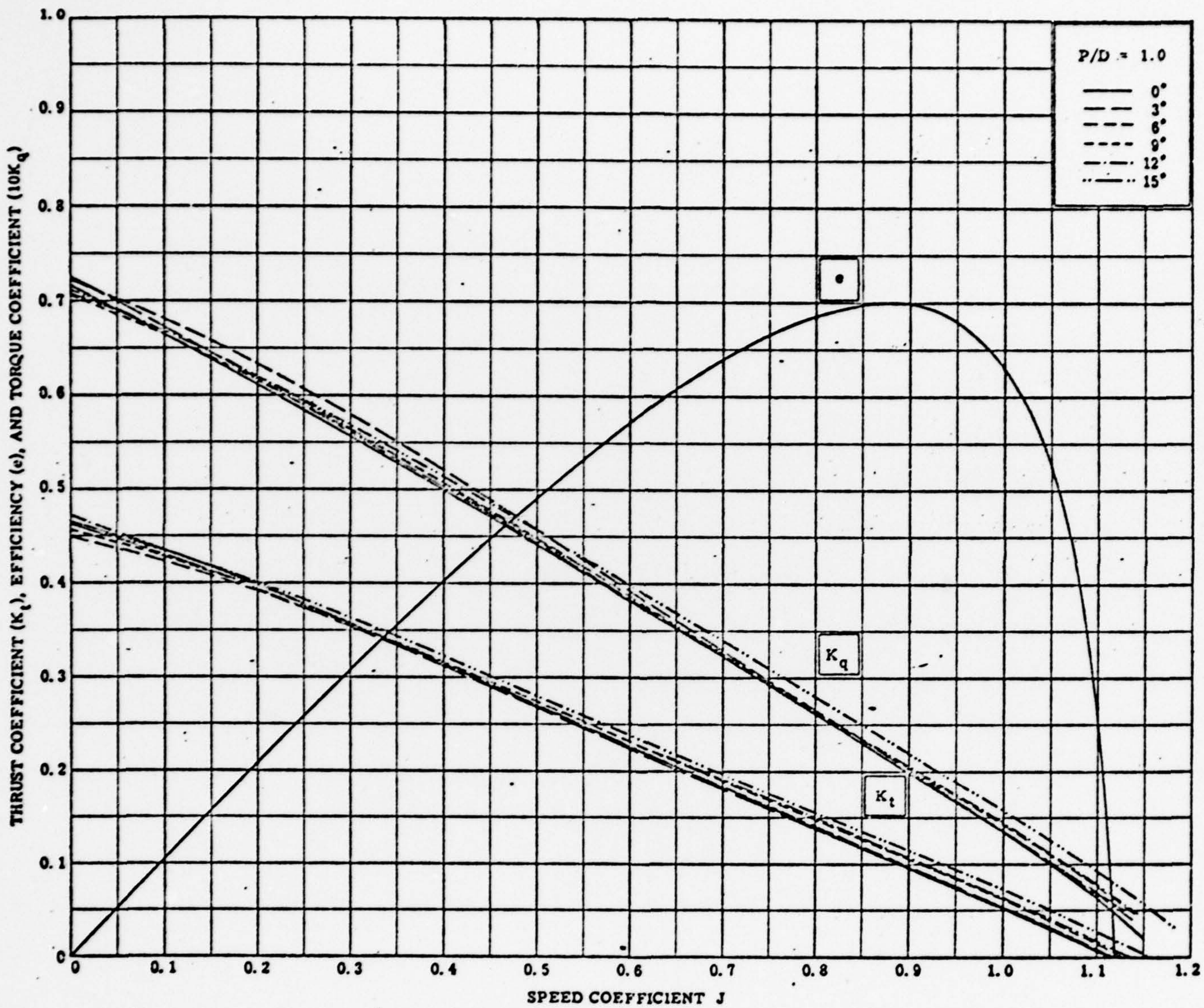


Figure 10 - Open-Water Characteristic Curves for a Pitch Ratio of 1.0 at Various Angles of Attack

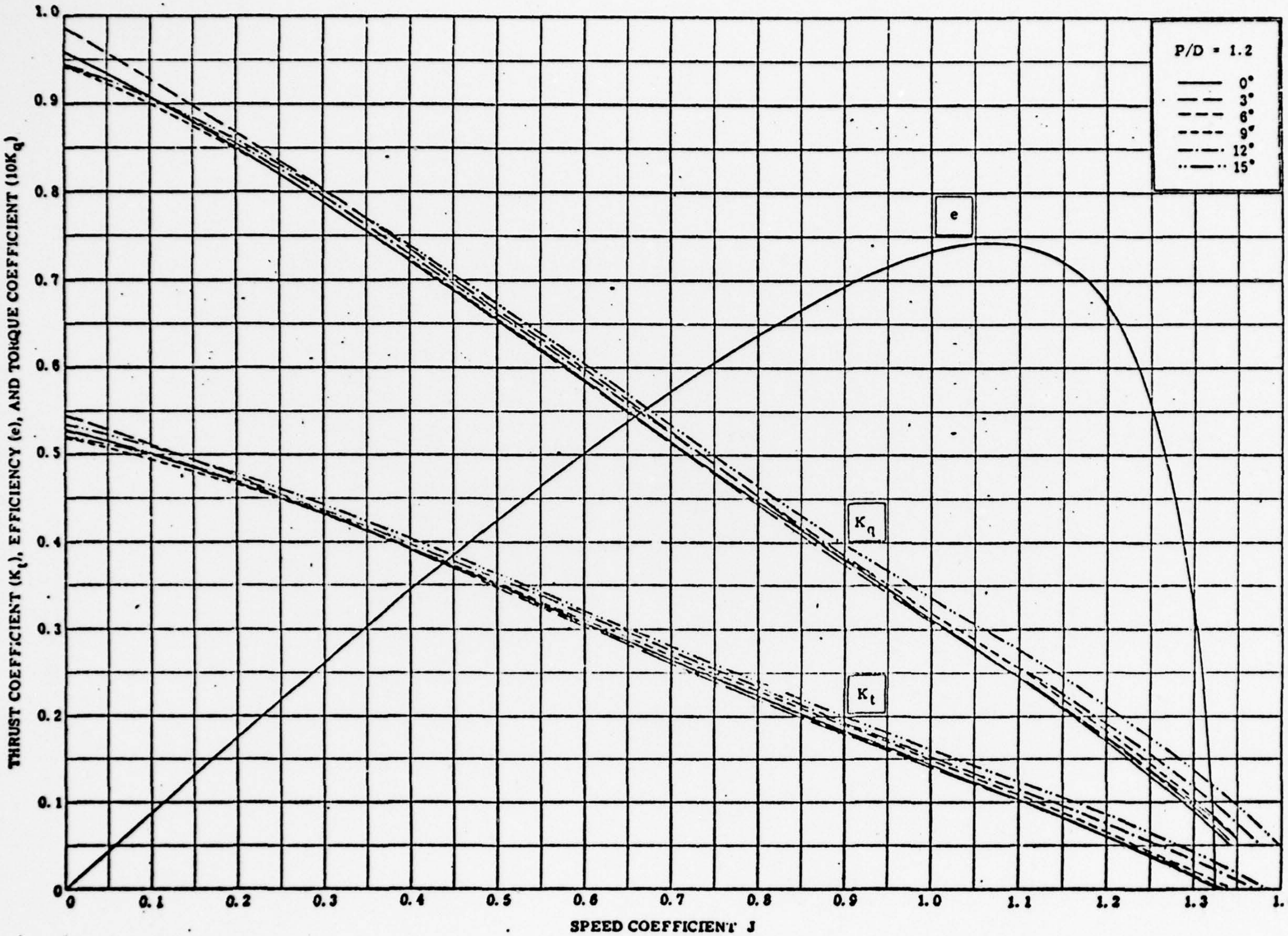


Figure 11 - Open-Water Characteristic Curves for a Pitch Ratio of 1.2 at Various Angles of Attack

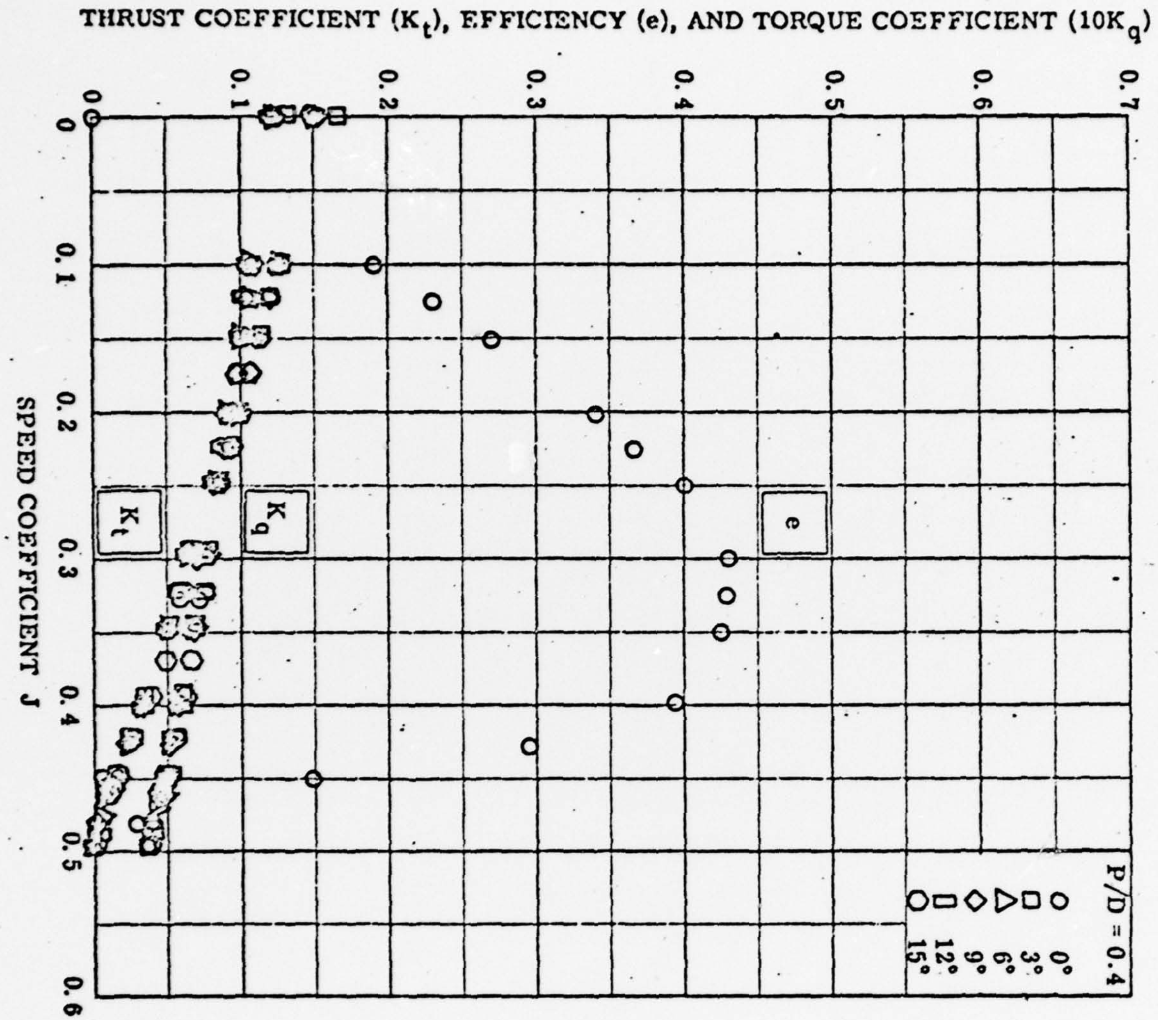


Figure 12 - Open-Water Characteristic Test Spots for a Pitch Ratio of 0.4 at Various Angles of Attack

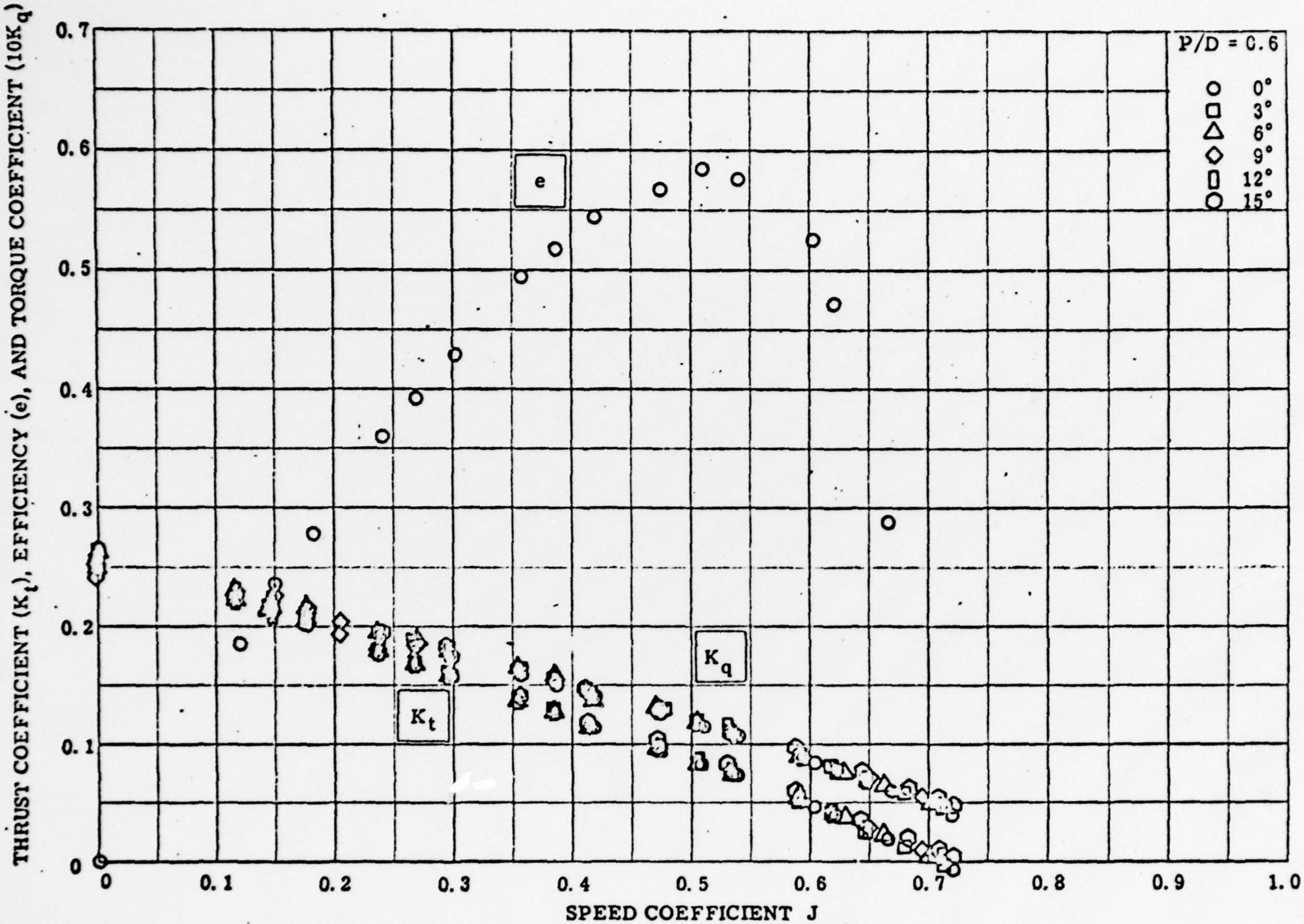


Figure 13 - Open-Water Characteristic Test Spots for a Pitch Ratio of 0.6 at Various Angles of Attack

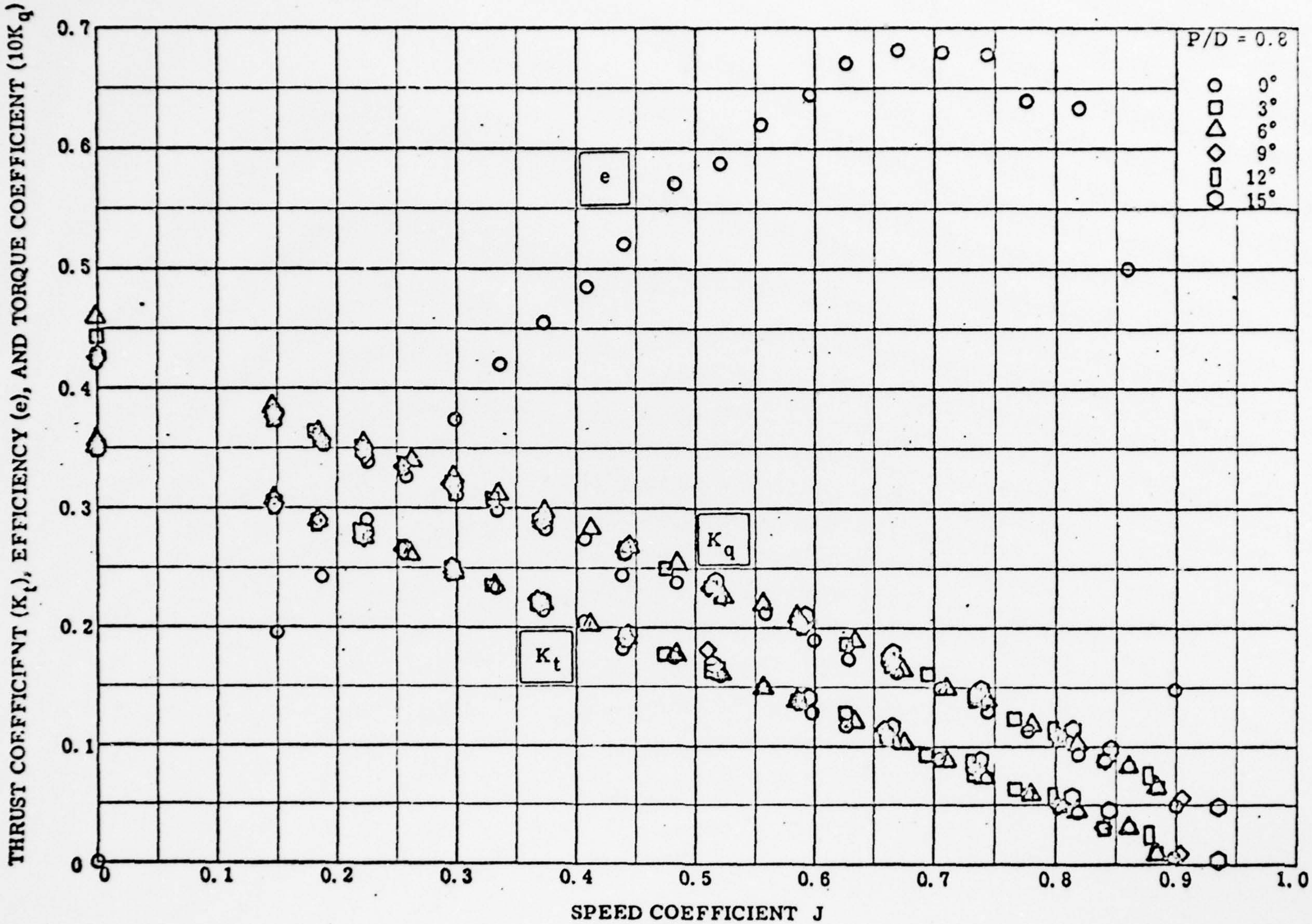


Figure 14 - Open-Water Characteristic Test Spots for a Pitch Ratio of 0.8 at Various Angles of Attack

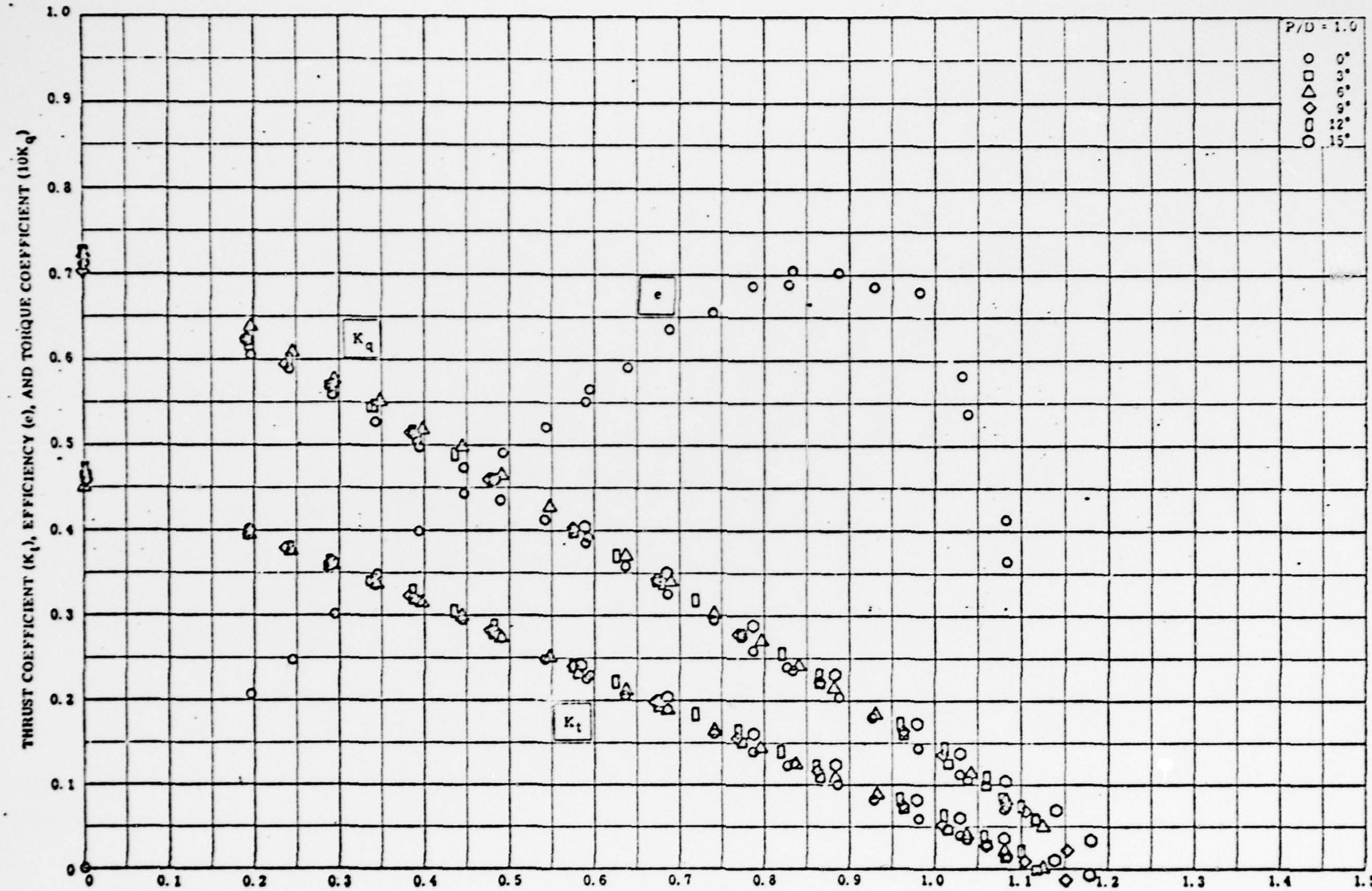


Figure 15 - Open-Water Characteristic Test Spots for a Pitch Ratio of 1.0 at Various Angles of Attack

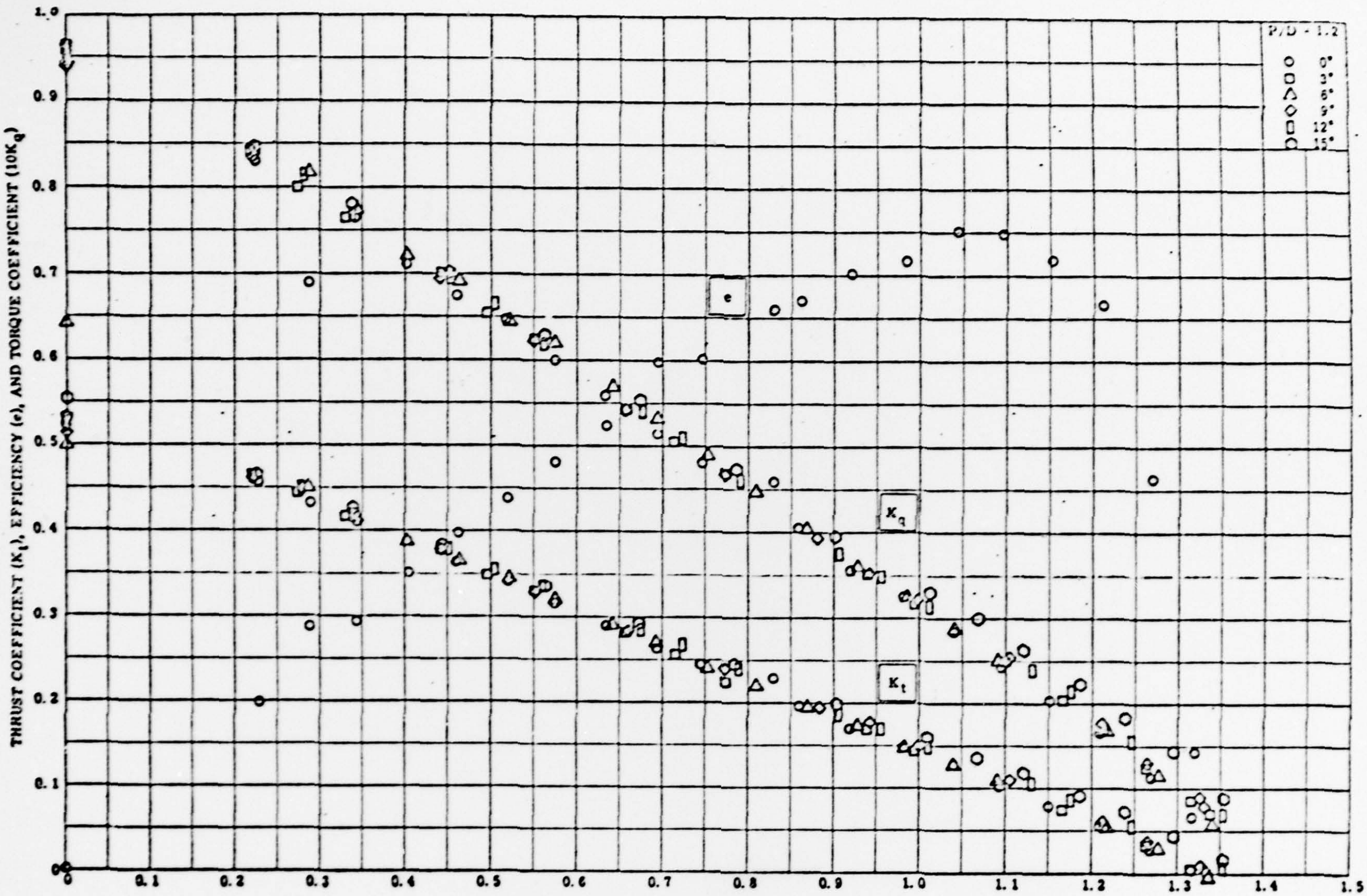


Figure 18 - Open-Water Characteristic Test Spots for a Pitch Ratio of 1.2 at Various Angles of Attack